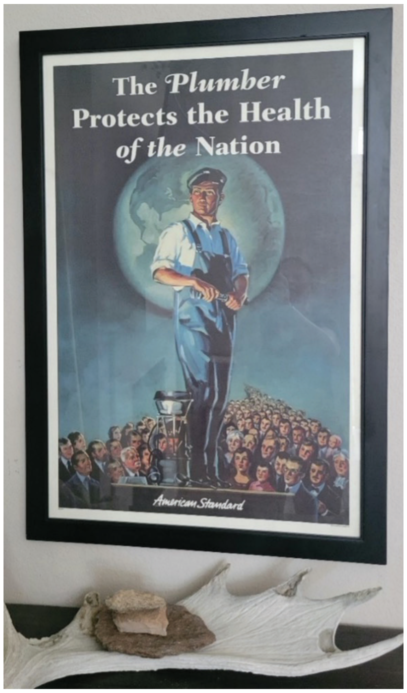
ICC INTERNATIONAL CODE COUNCIL®

Cross-Connection Control:

A Critical Line of Defense Against Potable Water Contamination

by Rich Anderson



As I write this article, I am reminded of the old American Standard advertisement, The Plumber Protects the Heath of the Nation poster. It hangs in my living room, and it is a constant reminder that plumbing/cross-connection control professionals help to provide us with potable water where we live, work, play and worship. Plumbers and building safety professionals alike protect our water supply. This starts with understanding how a water system works and how cross-connection control is regulated.

What is Cross-Connection?

Cross-connection is an actual or potential connection between a municipal water distribution system and any source which would affect the quality of water being delivered.

We take cross-connection control for granted, but it is critical for safe, clean drinking water. Most of us can go to a faucet, water bottle filler, or drinking fountain and get a drink of potable water. This is due largely to the fact that cross-connection control is an inherit plumbing design and installation component. Cross-connection control consists of various methods, assemblies, and devices, that when installed and maintained properly, safeguard our potable water.

When these controls fail, however, the results can be catastrophic.

Two Types of Cross-Connection

Potable water supply and distribution systems work on a positive pressure and there are two types of cross-connection: direct and indirect.

1. **Direct Cross-connection** A direct cross-connection means that the connection to the potable water system is subject to backpressure and back siphonage. Backpressure is when there is an elevation of pressure in the downstream piping greater than the supply pressure, creating a reversal of the normal direction of flow. Back siphonage happens when there is a reduction in the water pressure causing a sub-atmospheric pressure within the system.
2. **Indirection Cross-connection** Indirect cross-connection is only subject to back siphonage. One form of back siphonage could occur if the municipal water system was turned off due to a leak. Once the water supply no longer has positive pressure the result is less atmospheric pressure in the piping system creating the perfect situation for back siphonage.

What are Backflow and Back Siphonage?

Backflow is the unintended reversal flow of water in a piping system, and it can occur when these conditions are met:

1. There is a cross-connection, or a passage must exist between the potable water system and another source.
2. A hazard must exist in this other source to which the potable water is connected.
3. A hydraulic condition or either "back siphonage", or "backpressure" must occur.

Did you know?

Modern day backflow preventers were born from improvements made to the old swinging check valves or "Clappers" by installing multiple checks in a series along with a length of straight pipe between the checks.

There are multiple situations that could cause a backflow incident. We need to assume the worst possible situation that could occur and take the necessary steps to protect our water. Keep in mind that even temporary connections need to be evaluated and have proper protection applied.

Back siphonage is a form of backflow due to a reduction in system pressure causing a sub-atmospheric pressure in the piping system.

Backflow and back siphonage are harmful to people and to property because they create a risk for contamination. While they cause similar problems, they are remedied differently.

With these terms now defined, we can move onto determining the level of hazard. A containment or high hazard is any substance that would impair the quality of water creating a hazard to public health through poisoning or spread of disease. A pollutant or low hazard is an impairment to the quality of water that does not create a hazard to the public health but would adversely affect the quality of water being delivered.

Regulating Water Systems and Cross-Connection Control

Understanding whether you're dealing with a backflow or back siphonage condition is of the utmost importance in choosing the proper method, assembly, or device to protect your water. Failure to have proper protection will lead to an incident that will contaminate the potable water system.

Air gaps or the physical separation between the potable water source and the hazard is the best method of providing cross-connection control. However, this is not always possible. In many cases, the potable water line is directly connected to a non-potable source and must be protected in an approved manner.

Chapter 6, section 608 of the 2021 International Plumbing Code (IPC) is dedicated to the protection of potable water supply for all non- International Residential Code (IRC) regulated structures. Chapter 29, section P2902 of the IRC is dedicated to protection of potable water supply for all IRC regulated structures.

Table 608.1 in the 2021 IPC is a valuable resource for identifying types of backflow preventers as well as verifying what standards backflow preventers must adhere to and provides guidance on degree of hazard (Low or High Hazzard) and application (backpressure or back siphonage).

TABLE 608.1
APPLICATION OF BACKFLOW PREVENTERS

DEVICE	DEGREE OF HAZARD[a]	APPLICATION[b]	APPLICABLE STANDARDS
Backflow prevention assemblies:			
Double check backflow prevention assembly and double check fire protection backflow prevention assembly	Low hazard	Backpressure or backsiphonage Sizes 3/8″–16″	ASSE 1015; AWWA C510; CSA B64.5; CSA B64.5.1
Double check detector fire protection backflow prevention assemblies	Low hazard	Backpressure or backsiphonage Sizes 2″–16″	ASSE 1048
Pressure vacuum breaker assembly	High or low hazard	Backsiphonage only Sizes 1/2″–2″	ASSE 1020; CSA B64.1.2
Reduced pressure principle backflow prevention assembly and reduced pressure principle fire protection backflow assembly	High or low hazard	Backpressure or backsiphonage Sizes 3/8″–16″	ASSE 1013; AWWA C511; CSA B64.4; CSA B64.4.1
Reduced pressure detector fire protection backflow prevention assemblies	High or low hazard	Backsiphonage or backpressure (automatic sprinkler systems)	ASSE 1047
Spill-resistant vacuum breaker assembly	High or low hazard	Backsiphonage only Sizes 1/4″–2″	ASSE 1056; CSA B64.1.3
Backflow preventer plumbing devices:			
Antisiphon-type fill valves for gravity water closet flush tanks	High hazard	Backsiphonage only	ASSE 1002/ASME A112.1002/CSA B125.12; CSA B125.3
Backflow preventer for carbonated beverage machines	Low hazard	Backpressure or backsiphonage Sizes 1/4″–3/8″	ASSE 1022
Backflow preventer with intermediate atmospheric vents	Low hazard	Backpressure or backsiphonage Sizes 1/4″–3/4″	ASSE 1012; CSA B64.3
Backflow preventer with intermediate atmospheric vent and pressure-reducing valve.	Low hazard	Backpressure or backsiphonage Sizes 1/4″–3/4″	ASSE 1081
Dual-check-valve-type backflow preventer	Low hazard	Backpressure or backsiphonage Sizes 1/4″–1″	ASSE 1024; CSA B64.6
Hose connection backflow preventer	High or low hazard	Low head backpressure, rated working pressure, backpressure or backsiphonage Sizes 1/2″–1″	ASME A112.21.3; ASSE 1052; CSA B64.2.1.1
Hose connection vacuum breaker	High or low hazard	Low head backpressure or backsiphonage Sizes 1/2″, 3/4″, 1″	ASME A112.21.3; ASSE 1011; CSA B64.2; CSA B64.2.1
Laboratory faucet backflow preventer	High or low hazard	Low head backpressure and backsiphonage	ASSE 1035; CSA B64.7
Pipe-applied atmospheric-type vacuum breaker	High or low hazard	Backsiphonage only Sizes 1/4″–4″	ASSE 1001; CSA B64.1.1
Vacuum breaker wall hydrants, frost-resistant, automatic-draining-type	High or low hazard	Low head backpressure or backsiphonage Sizes 3/4″, 1″	ASME A112.21.3; ASSE 1019; CSA B64.2.2
Other means or methods:			
Air gap	High or low hazard	Backsiphonage or backpressure	ASME A112.1.2
Air gap fittings for use with plumbing fixtures, appliances and appurtenances	High or low hazard	Backsiphonage or backpressure	ASME A112.1.3
Barometric loop	High or low hazard	Backsiphonage only	(See Section 608.14.4)

For SI: 1 inch = 25.4 mm.

a. Low hazard—See Pollution (Section 202).
   High hazard—See Contamination (Section 202).

b. See Backpressure, low head (Section 202, Backflow).
   See Backsiphonage (Section 202, Backflow).

You can verify whether an assembly or device meets the required listings in table 608.1 by visiting the [ICC-ES PMG site] and searching for the listing, asking the design professional of record or the manufacturer for the required third-party testing per section 303.4 of the 2021 IPC.

Sections 608.2-608.17.10 of the 2021 IPC outline specific requirements based on the type of hazard the potable water line it is connected to. Included are items such as which plumbing fixtures need to be provided with backflow protection in accordance with ASME A112.18.1/CSA B125.1, as well as specific requirement for:

- Air gaps
- Connections to carbonated beverage dispenses
- Boiler connections
- Automatic sprinkler and standpipe protection
- Landscape irrigation
- Direct chemical injection

With all these specific life safety provisions dedicated to protecting our potable water, you can understand why I have relied on the IPC for guidance throughout my entire career.

Installing Your Cross-Connection Protection

Once you know how to choose the proper protection based on the level of hazard and application, you can then decide where to install our cross-connection method, device, or assembly.

One location where protection is provided is referred to as containment. This is when an assembly is installed at or near the service connection. Typically, we see this installed just downstream of the water meter. Containment protects the municipal water supply but will not protect the internal water distribution system in a building.

The other location where protection is provided is referred to as isolation. This protects the internal water distribution system, and there must be an isolation method, device or assembly installed at the point of connection to the source of the hazard. Simply put, an air gap on a faucet is a method of isolation protection. Failure to install isolation at the point of connection could result in an incident adversely affecting the quality of water to the last free flowing fixture on the property.

All Backflow assemblies and air gaps shall be inspected annually to determine if the assemblies are operable and that air gaps exist. Furthermore, there are specific requirements for testing specific assemblies at the time of installation and annually.

Examples

When testing a double check backflow prevention assembly, it needs to be tested using atmospheric pressure (14.7 PSI at sea level); when testing a reduced pressure principal pressure backflow prevention assembly, it is tested with internal water pressure. At first glance one could mistake these two different assemblies. The Watts 007 and the 009 are examples of two different types of backflow valves that look similar from the top of the valve. If you are not reading the data plate, you might attempt to test the assembly in an unapproved manner.

A barometric loop works on the specific gravity of water and vacuum.

- 2.31ft (of water column = 1psi) x 14.7 (atmospheric pressure at sea level) = 33.9ft.

Knowing the specific gravity and that in a perfect vacuum water can only be lifted to a point of 33.9 feet, installing a loop at 34 feet is a viable method of cross-connection control. Therefore, you would not test this method in the same way you would test a Pressure Vacuum Breaker. To verify this is properly installed, we measure from the highest free flowing water outlet to the top of the loop.

A properly sized thermal expansion tank on a closed system will prevent thermal expansion, thus preventing backpressure. There is no testing method for a thermal expansion tank. To properly size, we need to know the BTU of the heat source, total gallons of storage, supply pressure inlet pressure and final temperature of the water delivered etc. I have found that the Watt's expansion tank calculator, The Bradford white Thermal Expansion and your water heater handout, and the AO Smith expansion tank sizing guide to be good resources for a quick sizing reference. I am confident that other manufactures of expansion tanks and water heaters have similar resources.

Only personnel who are properly trained to test and rebuild backflow prevention devices or assemblies should do so. However, I will go over a few basic tips to help:

- Always be aware of your surroundings and notice if air gaps are present.
- Check hose bibs or mop sinks for cross-connection control. These are the number 1 locations where a cross-connection occurs. The cross-connection control device on most hose bibs and mops sinks is an atmospheric vacuum breaker (AVB). AVB's are required to be taken out of service for 12 hours in a 24-hour period. This means that the hose bib or mop sink faucet should not be under constant pressure or always turned on.
- In my experience, state or local water quality control or water utilities are responsible for administering cross-connection control programs. Each state or local jurisdiction might have differing requirements for installers, testers, and inspectors. They do often refer to the adopted plumbing code and add additional requirements. Work closely with your jurisdiction cross-connection control programs administer.
    - This person can help you understand local requirements for installation, testing, repairing/rebuilding, and documentation.
        - Documentation for testing should be part of any cross-connection control program and should follow industry standards. An example of the Texas Department of Commission on Environmental Quality (TCEQ) form can be found here.
- Perform a cross-connection control survey when conducting site surveys, installations, or inspections. This will help you identify any potential hazards and address them with the owners. TCEQ has a Customer Service Inspection guide document that can be found here.
- The state of Colorado Department of Public Health and Environment has a great website to assist communities in managing a program.
- When seeking out what qualifications are needed, you will have to check with the state or local jurisdictions for requirements. The ICC PMG Technical Resources team along with the ICC Teaching and Learning Center can provide targeted training upon request.
- An additional resource for designers, contractors, plans examiners and inspectors, is the ICC PMG Membership councils (PMG MC) CodeNotes™ on Backflow Preventer can be found here in English and here in Spanish.
- Always check with local jurisdiction to verify requirements for designing, installing, or testing backflow prevention protection.
- Always follow manufacture instructions, IPC and state or local requirements for testing. Never use any parts that are not specifically listed for the assembly or device you are repairing or rebuilding. Doing so would not be allowed per the listing of the assembly or device.

Whether you are a design professional, plumbing contractor, inspector, building owner or water user, we all share in keeping our water safe. If we come across a hazard, we need to educate others on the adverse conditions created and help with a solution. When in doubt always contact a local licensed professional to determine the level of hazard, application and what method, device or assembly is needed.

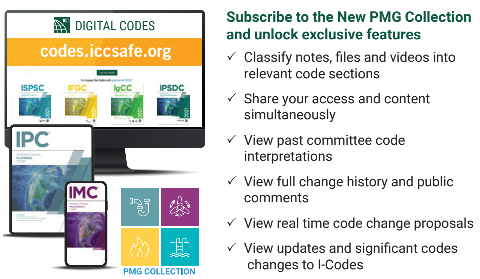
Resources and Training for Plumbing Professionals

Understanding IPC and IRC requirements for protection of potable water is paramount in a successful cross-connection control program. Furthermore, there are industry terms, mathematical equations/numbers, and definitions with which one must be familiar.

In my career, I attended various training courses and continuing education to stay current on cross-connection control. During my time as a plumbing contractor, I held a Backflow Prevention Assembly Tester (BPAT) License with the Texas Commission on Environmental Control (TCEQ). To fully grasp the complexities of testing and repairing/rebuilding assemblies, I was required to complete a 40-hour in classroom training to obtain the BPAT license as well as 24 hours of continuing education over a three-year period to renew it. The International Code Council offers this 40-hour BPAT class, and I highly recommend that all plumbing designers, contractors, and inspectors consider it.

Other resources I have found to be invaluable are:

- University of Southern California's Foundation for Cross-Connection-Control and Hydraulic Research Manual of Cross-Connection Control Tenth Edition
- American Backflow Prevention Association
- ICC ES PMG
- IPC
- IRC
- PMG Digital Codes premium package



I would also recommend building your network of plumbing and design professionals. You can do this by joining associations like the International Code Council, American Society of Plumbing Engineers, and the American Backflow Prevention Association, or volunteering to sit on their committees, boards, or councils. The ICC PMG Membership Council is a great way to connect with PMG code, design, standards, contractors, and educator professionals.

As I mentioned at the beginning of this article, everyone has a role to play. We as professionals can help educate the public by hosting community outreach events, performing annual inspections for cross-connection control, recognizing National Backflow Prevention Day (August 16), and hosting plumbing-focused public events during the International Code Council's annual Building Safety Month campaign. It takes a village to keep our water clean, and we can lead the way.

ABOUT THE AUTHOR

Richard "Rich" C. Anderson, CBO is a Director, PMG Technical Resources for the International Code Council. He has more than 23 years of experience working within the plumbing, mechanical and construction industry. Prior to the Code Council, Anderson was the Chief Building Official for the City of Fort Collins, Colorado; Deputy Building Official for the City of Amarillo, Texas; Division Manager/Commercial Inspections, City of Austin Development Services Department; Residential Inspections Supervisor, City of Austin Development Services; and Chief Plumbing/Mechanical/Irrigation Inspector, City of Amarillo, Texas. Prior to his work with local government, Anderson was a Plumbing and Mechanical Contractor in Amarillo, Texas, for over 13 years.

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